

Arsenic Release from Water Treatment Residuals: An Example of Proactive Environmental Engineering

The University of Arizona Superfund Basic Research Program

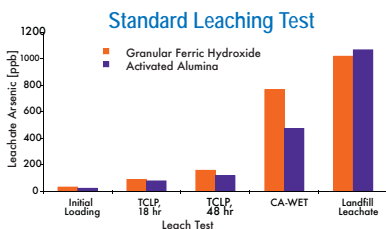
Wendell P. Ela, E. Sáez, M. Mukiibi, A. Ghosh, S. Fathoridoobadi, J. Shaw, B. Zelinski, M. Ramírez

Background

Recent passage of a more stringent arsenic in drinking water standard provides new impetus to manage arsenic in the environment from a full life management perspective. Fortunately, we still have the opportunity to act proactively and manage arsenic-bearing solid residuals (ABSR) so that their disposal does not negatively impact future human and environmental health.

What's the Problem?

Nationally it is estimated that approximately 6 million pounds of solid residuals containing approximately 30 thousand pounds of arsenic will be generated every year, and disposed in mixed solid waste (MSW) landfills. Most ABSRs tested to date pass the Toxicity Characteristic (TC) criteria and, consequently, are expected to be disposed in non-hazardous (MSW) landfills or other landfills approved by states. However, research indicates that the Toxicity Characteristic Leaching Procedure (TCLP), on which the TC regulation relies, underestimates leaching of arsenic from these residuals in mature MSW landfills. Some portion of the arsenic contained in these residuals will leach out and ultimately end up in the landfill leachate or the groundwater beneath the landfill.



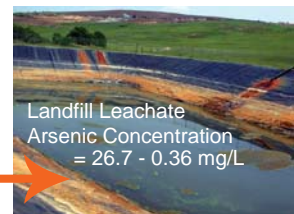
Arsenic concentration in the leachate solution after ABSR (Granular Ferric Hydroxide and Activated Alumina) were subjected to standard and modified batch leaching tests. The EPA standard test is the 18 hour TCLP. In California the 48 hour WET alternative is used. In the landfill leachate case, the leachate from an actual landfill was substituted for the acetic acid solution normally in the TCLP. The initial loading value is the concentration that leaches if exposed to water alone.

Who will be Impacted?

The revised arsenic MCL standard will ultimately impact about 4,000 drinking water utilities. EPA further estimates that over 95 % of those affected will be small utilities (serving less than 3,301 people). It is expected that these utilities will primarily implement arsenic removal using iron-based sorbents, which is the least costly and most efficient arsenic removal approach. The process residual is a poorly crystalline arsenic-bearing, iron solid.

Blackbox Mass Balance Model

Landfill Input = 2.24 gAs/capital*year
= 560 kgwaste/capital*year
0.15 - 11 Leachate/kgwaste



Landfill Leachate
Arsenic Concentration
= 26.7 - 0.36 mg/L

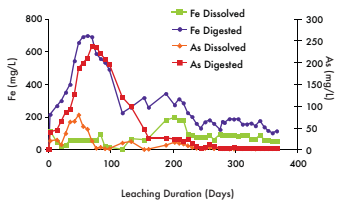
Project Methodology

A two-phase research project evolved to evaluate the consequences of this disposal strategy.

The **first phase** focused on understanding the behavior of arsenic-bearing solid residuals (ABSR) after disposal in MSW landfills with a particular emphasis on the likelihood of remobilization of arsenic from the ABSR. The results of initial trials evaluating the efficacy of standard leaching tests (such as the TCLP) motivated follow-on work to more accurately simulate the bio-geochemical processes affecting arsenic stability in a MSW landfill. To this end, carbon rich, continuous flow columns were utilized to simulate iron solid behavior in mixed waste landfills and in the reducing zones in sediments and soils.

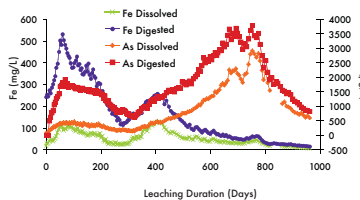
The **second phase** of the project, motivated by the phase 1 conclusion that arsenic in ABSR will be readily released in landfills, undertook an evaluation of two means by which arsenic might be stabilized on ABSR. Low-heat incubation was used to accelerate and study arsenic retention after iron solid aging with an eye to possible improved arsenic retention with increased iron crystallization. Combined physical/chemical stabilization of ABSR was also investigated using conventional cement stabilization as well as an innovative polymeric encapsulation method.

AFH - Particle Transport



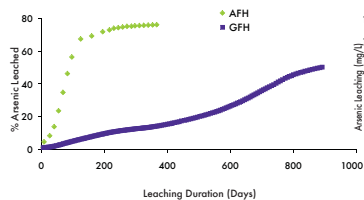
Total versus dissolved arsenic and iron in AFH column effluent. The difference between the total and dissolved concentrations represents leached As and Fe in particulates.

GFH - Particle Transport



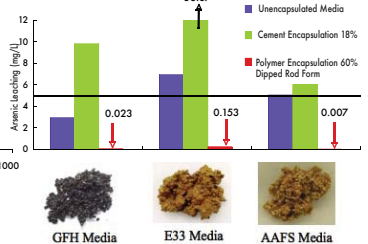
Total versus dissolved arsenic and iron in GFH column effluent. The difference between the total and dissolved concentrations represents leached As and Fe in particulates.

Arsenic Leached with Time



Cumulative mass fraction of arsenic leached from GFH and AFH columns as a function of time. The difference can be explained by the nature of the two iron-oxide sorbents themselves. The iron in GFH is more crystalline and stable than the amorphous AFH.

Traditional vs. Innovative Encapsulation



Unencapsulated ABSRs leach close to or above the TC limit. Traditional cement encapsulated ABSR leach arsenic at higher levels than the unencapsulated ABSRs. Polymer encapsulation reduces leaching by a factor of 15 or more. Cement has a maximum waste loading of 18% while polymer loading is 60% or higher.

Conclusions

- TCLP significantly underestimates arsenic leaching from ABSR. Non-hazardous landfill disposal of ABSR is currently allowed, however, ABSR placed in landfill simulation columns leached arsenic near or above the TC.
- ABSR leach As in landfill simulations primarily in a particulate-associated or reduced state. Neither of these are simulated in standard leaching tests. Both promote increased mobility in groundwater environments.
- Low cost cement, the conventional means of stabilization, increases arsenic leaching compared to the unstabilized case. Arsenic leaching from ABSR stabilized by a low cost, organic polymer encapsulation method is reduced by a factor of 30 to 100.
- If ABSRs are generated, the unstabilized ABSR should not be disposed in unlined landfills. If disposed in lined landfills, ABSRs may impact how the landfill leachate should be handled and managed. Based on the current state of knowledge, the most environmentally benign disposal strategies for ABSR are either consignment to hazardous waste sites or stabilization by polymeric encapsulation.